

AN-2057 LM3559/LM3560 Evaluation Board

1 Introduction

The LM3559/LM3560 Evaluation Board is designed to fully evaluate the LM3559 and LM3560 Synchronous Boost Converter with dual 900mA High Side Flash LED Drivers (LM3559) or dual 1000mA High Side Flash Drivers (LM3560) and I²C-Compatible Interface. Detailed descriptions for either parts can be found in their device-specific data sheets.

The board comes equipped with two Lumiled Flash LEDs (LXCL-EYW4). An additional LED (LED3) is a red LED which operates as the message indicator. The on-board flash button demonstrates the hardware flash feature of the LM3559/LM3560 and, when pushed, the Flash LEDs turn on at their programmed Flash current. There are two 4.7k Ω pull-up resistors on board for the I²C clock and data lines and a 4.7k Ω pull-up (R_HWEN) that pulls the active high hardware enable pin (HWEN) high. Each Input and/or output from the LM3559 has its own separate header pin to serve as a test-point.

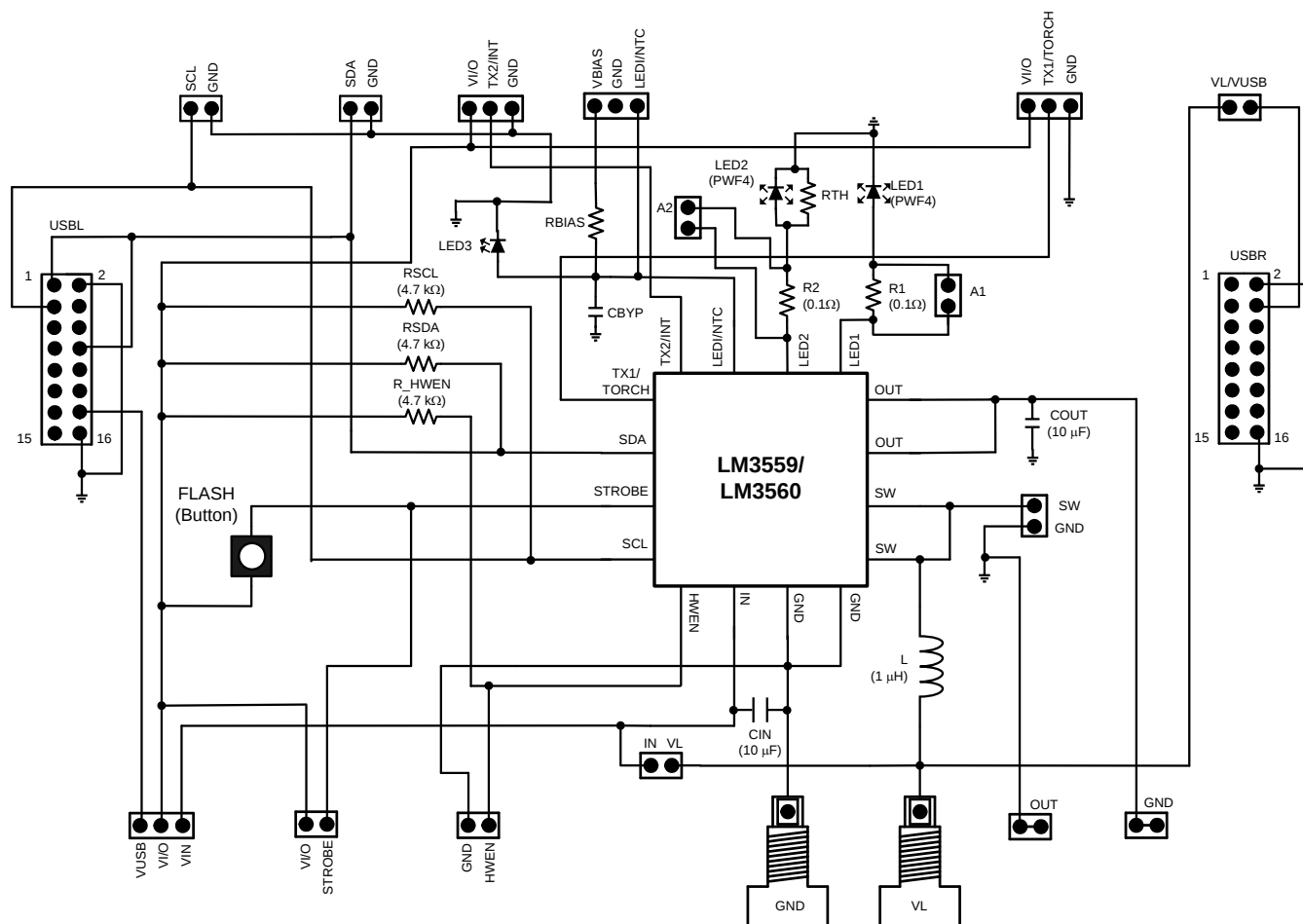


Figure 1. LM3559/LM3560 Evaluation Board Schematic

All trademarks are the property of their respective owners.

2 Evaluation Board Bill of Materials

Table 1. Board Bill of Materials

Component	Manufacturer	Value	Part Number	Size (mm)	Description
L	TOKO	1.0 μ H	FDSD0312-1R0M	3x3x1.2	$I_{SAT} = 3.4A$ (43 m Ω)
COUT	Murata	10 μ F	GRM188R60J106M	0603 (1.6 x 0.8)	6.3V, X5R
CIN	Murata	10 μ F	GRM188R60J106M	0603 (1.6 x 0.8)	6.3V, X5R
LED1, LED2	Lumiled	Flash LED	LXCL-EYW4	(2.04 x 1.64 x 0.7)	145 lm (1A), VF = 3.6V, @1A
LED3	Stanley Electric or equivalent	Red LED	HKR1105W-TR	1206 (3.2 x 1.6)	Red LED (20 mA max)
R1, R2	Panasonic	100 m Ω	ERJ-L06KF10CV	0805 (2 x 1.2)	1/8W, 1% Sense resistors for LED current
RTH (not populated)					
R_PU, RSDA, RSCL	Vishay	4.7 k Ω	CRCW06034700F	0603 (1.6 x 0.8)	
R3 (not populated)					
Flash Button	Panasonic		EVQP1		Momentary push-button
USBL, USBR					USB Interface Board Connector

3 Operation

To operate the LM3559/LM3560 evaluation board, connect a jumper from the VI/O pin to the IN pin (3-pin header at bottom left of board). This connects the logic level pull-ups to VIN. Next, connect a jumper across the IN VL header. This will short the IN pin and the input terminal of the inductor. This jumper is designed to remove the input bypass capacitor from the input of the inductor to measure the inductor current ripple. With these jumpers in place, connect a 2.5V to 5V supply between the VL banana jack and GND.

Control of the LM3559/LM3560 can be done via two ways. At the top left corner of the board there are two 2-pin headers (SCL/GND and SDA/GND). To control the LM3559/LM3560 using a data generator or an external I²C device connect the I²C lines directly to the SCL and SDA pins of the respective header. Alternatively you can use the Texas Instruments USB board to supply the I²C data (see [Section 3.1](#)).

3.1 Operation With Texas Instruments USB Interface

The USBL and USBR connectors (16 pin connectors mounted on the bottom of the board) plug directly into the Texas Instruments USB Interface Board. The connectors are keyed so the boards will fit together only one way. The 3-position header at the bottom of the board (VUSB VI/O VIN) connects the evaluation boards pull-up resistors, tied to VI/O, to either VIN or to the 3.3V regulator (VUSB) from the USB board. Connecting a jumper across VIN/VUSB at the top right of the board allows for power (at the VL pin) to come from the USB Interface Board. This is useful for demonstrating the device without an external power supply. Keep in mind that the USB board has a 500 mA current limit and is either 3V or 5V depending on the (J1) jumper setting on the USB Interface Board (for details, see the USB Interface Module for Applications document). High-current requirements such as high Flash mode and higher Torch mode currents will require an external supply at VL. Also ensure the VIN/VUSB jumper is left open when connecting an external supply to the VL plugs as this will cause a conflict with the power supply from the Interface Board and the external supply connected to VL.

After power is applied to the LM3559/LM3560 Evaluation Board, connect the USB Interface Board to a PC with the LM3559.exe or LM3560.exe program installed. The LM3559.exe and LM3560.exe programs are simple executables that can be copied to a folder on the PC. (see [Figure 2](#) and [Figure 3](#)).

The screenshot displays the LM3559 .exe graphical user interface. It features a 'Simple I2C Interface' section at the top left with 'Write' and 'Read' buttons, an 'I2C Address' field set to 53, and a 'Default' button. Below this is the 'Enable Register (0x10)' with bit fields for EN Blink, EN M.I., STR, LED2, LED1, EN1, and EN0, along with a 'Flash' button. The 'Torch Brightness Register (0xA0)' and 'Flash Brightness Register (0x80)' are shown with current settings of 84.375mA and 787.5mA respectively. The 'Flash Duration Register (0xC0)' is set to 3.5A and 512ms. The 'VIN Monitor Register (0x80)' shows thresholds at 3.1V. The 'Privacy Register (0x11)' is configured for Privacy mode with a 10% duty cycle. The 'Indicator Register (0x12)' and 'Indicator Blinking Register (0x13)' are also visible. The 'Configuration Register 1 (0xE0)' and 'Configuration Register 2 (0xF0)' show various enable and shutdown options. The 'GPIO Register (0x20)' is set to 0. On the right side, the 'VLED Monitor Register (0x30)' shows VLED < 3.2V, and the 'ADC Delay Register (0x31)' is set to 250us. The 'Flags Register (0xD0)' shows various status bits like VIN Mon, VIN Flash Mon, NTC Fault, TX2 Int, TX1 Int, LED Fault, Thermal Shutdown, and Flash Timeout. The 'Last Flash Register (0x81)' shows a last flash read of 00. At the bottom left, a 'USB Initialization Error' message is displayed.

Figure 2. LM3559 Graphical User Interface

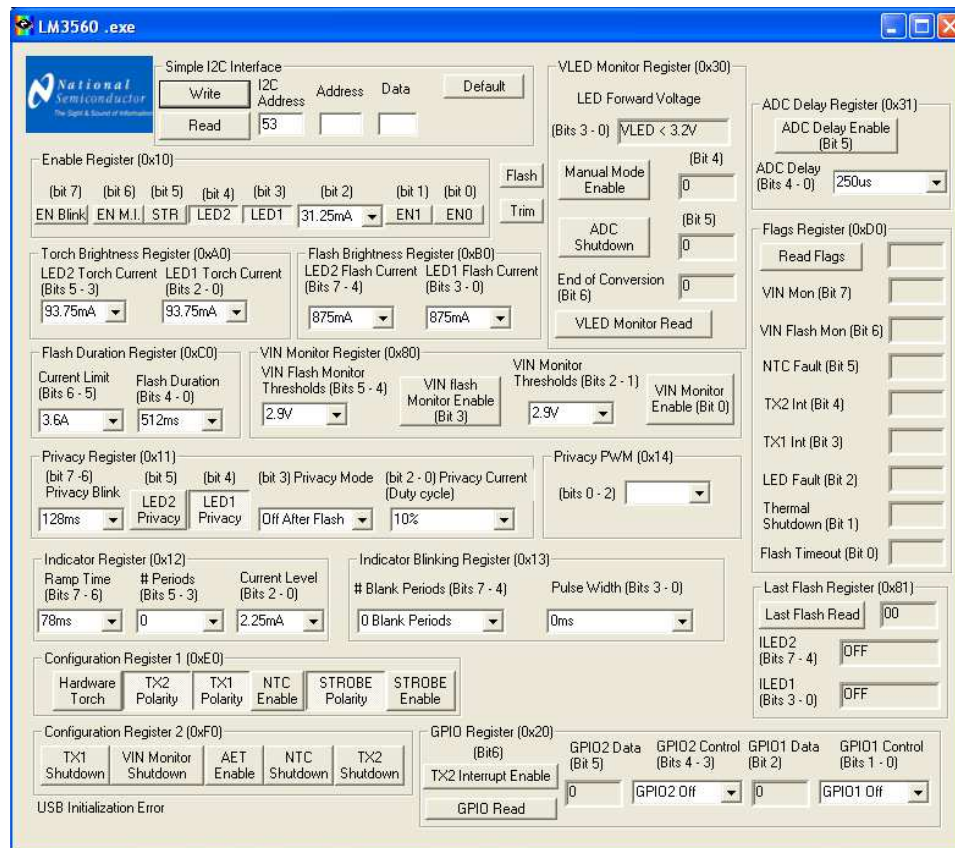


Figure 3. LM3560 Graphical User Interface

3.2 LM3559 Graphical User Interface

The LM3559 graphical user interface features all the register options that are programmable within the LM3559. When the LM3559.exe program is executed and any button is pressed or drop down box is selected, the program will automatically update the LM3559 with the settings of the appropriate register. When starting up the LM3559.exe program the screen displays the default (power on/reset) settings of the device. The Default button in the program will write all the LM3559 registers to their default state and populate the LM3559.exe with the default information.

3.3 LM3560 Graphical User Interface

The LM3560 graphical user interface operates similar to the LM3559. The differences are: bit 2 in the Enable Register (0x10) in the LM3560.exe has the option for 2 levels of Privacy Mode Current, the Torch and Flash Current nominal settings are different, the LM3560.exe's Configuration Register 2 (0xF0) reflects the additional option for a TX1 Shutdown, and the VLED Monitor Register nominal thresholds are different between devices.

The Following sections detail each different field within the LM3559.exe/LM3560.exe program.

3.4 Simple I²C Interface

The top three fields (I²C Address, Address, and Data) provide for a simple way of writing directly to the registers of the LM3559/LM3560. The I²C Address field shows the I²C slave address (0x53). The I2C (hex) address is written into the Address field and the I2C (hex) data is written in the Data field. The Write Button will write the contents to the LM3559/LM3560 and the Read button reads back the (hex) data.

3.5 Default

The Default button will automatically write all the internal registers to their default state and update the program to the default state.

3.6 Enable Register

The Enable Register section contains buttons for each bit that is programmable within the LM3559/LM3560's enable register.

Table 2. Enable Register Description (0x10)

Blink Enable (Bit 7)	Message Indicate Enable (Bit 6)	STROBE Level/Edge (Bit 5)	LED2 Enable (Bit 5)	LED1 Enable (Bit 4)	Privacy Mode Peak Current (LM3560 only) (Bit 2)	EN2 (Bit 1)	EN1 (Bit 0)
0 = Message Indicator Blinking Function is disabled (See Note below). (default) 1 = Message Indicator Blinking Function is enabled. The message indicator blinks the pattern programmed in the Indicator Register and Indicator Blinking Register	0 = Message Indicator is disabled (default) 1 = Message Indicator is enabled.	0 = (Level Sensitive) When STROBE goes high, the Flash current will turn on and remain on for the duration the STROBE pin is held high or when Flash Timeout occurs, whichever comes first (default) 1 = (Edge Triggered) When STROBE goes high the Flash current will turn on and remain on for the duration of the Flash Time-out.	0 = LED2 off 1 = LED2 on (default)	0 = LED1 off 1 = LED1 on (default)	0 = 31.25mA (default) 1 = 250mA	Enable Bits 00 = Both Current Sources are Shut Down (default) 01 = Indicator Mode 10 = Torch Mode 11 = Flash Mode (bits reset at timeout)	

NOTE: Bit 7 Enables/Disables the Message Indicator Blinking Function. With this bit set to 0 and Bit 6 set to 1, the Message Indicator turns on constantly at the programmed current as set in the Indicator Register, bits [2:0].

3.7 Flash Button

The Flash button automatically writes Register 0x10 (bits 0 and 1 high), enabling flash mode. At the end of the flash event, bit 1 is automatically written with a 0 and bit 0 is either left as a 1 or set to 0 depending on the state of the Privacy Mode bit (bit 3 in register 0x11).

3.8 Torch Brightness Field

The Torch Brightness field contains the drop down menu for selecting the torch current in either LED1 or LED2. Once the drop down data is selected the register data is automatically written to the LM3559/LM3560.

Table 3. Torch Brightness Register Description (Address 0xA0), LM3559

Not Used (Bit 7)	Not Used (Bit 6)	TC2A (Bit 5)	TC2B (Bit 4)	TC2C (Bit 3)	TC1A (Bit 2)	TC1B (Bit 1)	TC1C (Bit 0)
N/A		LED2 Torch Current Select Bits			LED1 Torch Current Select Bits		
		0 = 28.125 mA			0 = 28.125 mA		
		1 = 56.25 mA			1 = 56.25 mA		
		2 = 84.375 mA (default)			2 = 84.375 mA (default)		
		3 = 112.5 mA			3 = 112.5 mA		
		4 = 140.625 mA			4 = 140.625 mA		
		5 = 168.75 mA			5 = 168.75 mA		
		6 = 196.875 mA			6 = 196.875 mA		
		7 = 225 mA			7 = 225 mA		

Table 4. Torch Brightness Register Description (Address 0xA0), LM3560

Not Used (Bit 7)	Not Used (Bit 6)	TC2A (Bit 5)	TC2B (Bit 4)	TC2C (Bit 3)	TC1A (Bit 2)	TC1B (Bit 1)	TC1C (Bit 0)
N/A		LED2 Torch Current Select Bits			LED1 Torch Current Select Bits		
		0 = 31.25 mA			0 = 31.25 mA		
		1 = 62.5 mA			1 = 62.5 mA		
		2 = 93.75 mA (default)			2 = 93.75 mA (default)		
		3 = 125 mA			3 = 125 mA		
		4 = 156.25 mA			4 = 156.25 mA		
		5 = 187.5 mA			5 = 187.5 mA		
		6 = 218.75 mA			6 = 218.75 mA		
		7 = 250 mA			7 = 250 mA		

3.9 Flash Brightness Register

The Flash Brightness Register field contains drop-down menus for both LED1 and LED2. Once any drop-down menu selection is chosen the data is automatically written to the device.

Table 5. Flash Brightness Register Descriptions (Address 0xB0), LM3559

FC2A (Bit 7)	FC2B (Bit 6)	FC2C (Bit 5)	FC2D (Bit 4)	FC1A (Bit 3)	FC1B (Bit 2)	FC1C (Bit 1)	FC1D (Bit 0)
Flash Current Select Bits				Flash Current Select Bits			
00 = 56.25 mA				00 = 56.25 mA			
01 = 112.5 mA				01 = 112.5 mA			
02 = 168.75 mA				02 = 168.75 mA			
03 = 225 mA				03 = 225 mA			
04 = 281.25 mA				04 = 281.25 mA			
05 = 337.5 mA				05 = 337.5 mA			
06 = 393.75 mA				06 = 393.75 mA			
07 = 450 mA				07 = 450 mA			
08 = 506.25 mA				08 = 506.25 mA			
09 = 562.5 mA				09 = 562.5 mA			
0A = 618.75 mA				0A = 618.75 mA			
0B = 675 mA				0B = 675 mA			
0C = 731.25 mA				0C = 731.25 mA			
0D = 787.5 mA				0D = 787.5 mA			
0E = 843.75 mA				0E = 843.75 mA			
0F = 900 mA				0F = 900 mA			

Table 6. Flash Brightness Register Descriptions (Address 0xB0), LM3560

FC2A (Bit 7)	FC2B (Bit 6)	FC2C (Bit 5)	FC2D (Bit 4)	FC1A (Bit 3)	FC1B (Bit 2)	FC1C (Bit 1)	FC1D (Bit 0)
Flash Current Select Bits 00 = 62.5 mA 01 = 125 mA 02 = 187.5 mA 03 = 250 mA 04 = 312.5 mA 05 = 375 mA 06 = 437.5 mA 07 = 500 mA 08 = 562.5 mA 09 = 625 mA 0A = 687.5 mA 0B = 750 mA 0C = 812.5 mA 0D = 875 mA Default 0E = 937.5 mA 0F = 1000 mA				Flash Current Select Bits 00 = 62.5 mA 01 = 125 mA 02 = 187.5 mA 03 = 250 mA 04 = 312.5 mA 05 = 375 mA 06 = 437.5 mA 07 = 500 mA 08 = 562.5 mA 09 = 625 mA 0A = 687.5 mA 0B = 750 mA 0C = 812.5 mA 0D = 875 mA Default 0E = 937.5 mA 0F = 1000 mA			

3.10 Flash Duration Register

This field contains two drop-down menus to program the Flash Duration Register (address 0xC0) with the Flash Time-Out data and Current Limit Data. Once any of these values are set the Flash Duration Register is automatically updated with the new data. [Table 7](#) shows the bit settings for the Flash Duration Register.

Table 7. Flash Duration Register Descriptions (Address 0xC0)

Not used (Bit 7)	CL1 (Bit 6)	CL0 (Bit 5)	T4 (Bit 4)	T3 (Bit 3)	T2 (Bit 2)	T1 (Bit 1)	T0 (Bit 0)
N/A	Current Limit Select Bits (LM3559) 00 = 1.4A Peak Current Limit 01 = 2.1A Peak Current Limit 10 = 2.8A Peak Current Limit 11 = 3.5A Peak Current Limit (default) Current Limit Select Bits (LM3560) 00 = 1.6A Peak Current Limit 01 = 2.3A Peak Current Limit 10 = 3.0A Peak Current Limit 11 = 3.6A Peak Current Limit (default)		Flash Time-out Select Bits 00 = 32 ms time-out 01 = 64 ms time-out 02 = 96 ms time-out 03 = 128 ms time-out 04 = 160 ms time-out 05 = 192 ms time-out 06 = 224 ms time-out 07 = 256 ms time-out 08 = 288 ms time-out 09 = 320 ms time-out 0A = 352 ms time-out 0B = 384 ms time-out 0C = 416 ms time-out 0D = 448 ms time-out 0E = 480 ms time-out 0F = 512 ms time-out (default) 10 = 544 ms time-out 11 = 576 ms time-out 12 = 608 ms time-out 13 = 640 ms time-out 14 = 672 ms time-out 15 = 704 ms time-out 16 = 736 ms time-out 17 = 768 ms time-out 18 = 800 ms time-out 19 = 832 ms time-out 1A = 864 ms time-out 1B = 896 ms time-out 1C = 928 ms time-out 1D = 960 ms time-out 1E = 992 ms time-out 1F = 1024 ms time-out				

3.11 VIN Monitor Register

The VIN Monitor Register field contains 2 buttons and 2 drop-down menus to program the VIN Flash Monitor and the VIN Monitor. The VIN Flash Monitor Enable button and the VIN Monitor Button control the VIN Flash Monitor Enable and VIN Monitor Enable bits respectively. The 2 drop-down menus program the comparator thresholds for the respective monitor. Once any button is pushed or drop-down menu is selected the register data is automatically written.

Table 8. VIN Monitor Register (Address 0x80), LM3559

Bit 7 Not Used	Bit 6 Not Used	Bit 5 (VIN Flash Monitor Threshold)	Bit 4 (VIN Flash Monitor Threshold)	Bit 3 (VIN Flash Monitor Enable)	Bit 2 (VIN Monitor Threshold)	Bit 1 (VIN Monitor Threshold)	Bit 0 (VIN Monitor Enable)
N/A	N/A	00 = 3.1V (default) 10 = 3.2V 10 = 3.3V 11 = 3.4V		0 = VIN Flash Monitor is Disabled (default) 1 = VIN Flash Monitor is Enabled	00 = 3.1V (default) 10 = 3.2V 10 = 3.3V 11 = 3.4V		0 = VIN Monitor Disabled (default) 1 = VIN Monitor Enabled

Table 9. VIN Monitor Register (Address 0x80), LM3560

Bit 7 Not Used	Bit 6 Not Used	Bit 5 (VIN Flash Monitor Threshold)	Bit 4 (VIN Flash Monitor Threshold)	Bit 3 (VIN Flash Monitor Enable)	Bit 2 (VIN Monitor Threshold)	Bit 1 (VIN Monitor Threshold)	Bit 0 (VIN Monitor Enable)
N/A	N/A	00 = 2.9V (default) 10 = 3.0V 10 = 3.1V 11 = 3.2V		0 = VIN Flash Monitor is Disabled (default) 1 = VIN Flash Monitor is Enabled	00 = 2.9V (default) 10 = 3.0V 10 = 3.1V 11 = 3.2V		0 = VIN Monitor Disabled (default) 1 = VIN Monitor Enabled

3.12 Privacy Register

The Privacy Register contains the drop-down menus and push buttons to select the duty cycle of the Privacy PWM Period. The Privacy Current (Duty Cycle), selects the percentage of the Privacy PWM period that the LED current is on. The LED current in Privacy mode is equal to the minimum Torch current (LM3559) or selectable between the minimum Torch current or maximum Torch current (LM3560). The Privacy Mode selects whether Privacy mode remains on or turns off after a flash current pulse. The two buttons (LED1 Privacy and LED2 Privacy) enable LED1 or LED2 during Privacy mode. Privacy Blink selects the blinking period for the Privacy Mode. [Figure 4](#) displays the Privacy Indicator timing.

Table 10. Privacy Register (Address 0X11)

Privacy PWM Period (Bits 7 - 6)	LED2 On During Privacy Mode (Bit 5)	LED1 On During Privacy Mode (Bit 4)	Privacy Mode (Bit 3)	Privacy Current Duty Cycle (Bits 2 - 0)
00 = Always On 01 = 128 ms (Default) 10 = 256 ms 11 = 512ms	0 = LED2 current source is off during privacy mode (Default) 1 = LED2 current source is on during privacy mode	0 = LED1 current source is off during privacy mode 1 = LED1 current source is on during privacy mode (Default)	0 = Privacy mode turns off after the flash pulse 1 = Privacy mode remains on after the flash pulse (Default)	Privacy Mode Current Duty Cycle (% of min Torch Current) 000 = 10% (Default) 001 = 20% 010 = 30% 011 = 40% 100 = 50% 101 = 60% 110 = 70% 111 = 80%

3.13 Privacy PWM Register

The Privacy PWM register field contains a drop-down menu which selects the Privacy PWM period setting. Once a menu item is selected the Privacy PWM Register is automatically written with the selected data. The Privacy PWM Period is the pulse period of the LED current when the device is in privacy mode. [Figure 4](#) displays the Privacy Indicator timing. [Table 11](#) shows the bit settings for this register.

Table 11. Privacy PWM Period Register (Address 0x14)

Bits 7 - 3 (Not used)	Bit 2	Bit 1	Bit 0
N/A	000 = 5.12ms (Default) 001 = 2.56 ms 010 = 1.28 ms 011 = 640 μ s 1XX = 320 μ s		

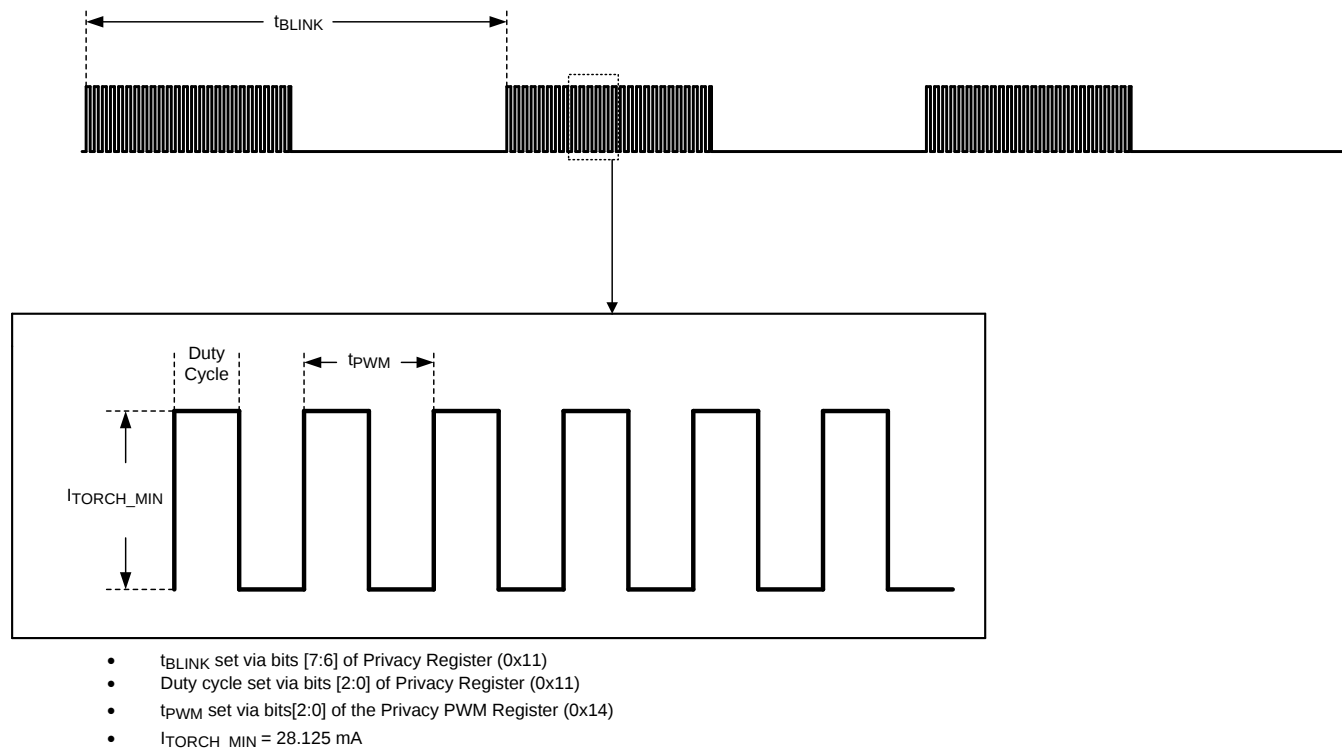


Figure 4. Privacy Indicator Timing

3.14 Indicator Register

The Indicator Register field contains three drop-down menus that control the Indicator Current Level, number of Indicator Periods, and the ramp time of the indicator current (from 0 to the programmed current level). See [Figure 5](#) for Message Indicator Timing. Once a drop-down menu is selected the Indicator Register is automatically updated with the new register data.

Table 12. Indicator Register (Address 0x12)

Bits 7 - 6 (Ramp Time ($t_R = t_F$))	Bits 5 - 3 (# Pulses)	Bits 2 - 0 (Current Level (I_{IND}))
00 = 78 ms (Default) 01 = 156 ms 10 = 312 ms 11 = 624 ms	000 = 0 (Default) 001 = 1 010 = 2 011 = 3 100 = 4 101 = 5 110 = 6 111 = 7	000 = 2.3 mA (Default) 001 = 4.6 mA 010 = 6.9 mA 011 = 9.2 mA 100 = 11.5 mA 101 = 13.8 mA 110 = 16.1 mA 111 = 18.4 mA

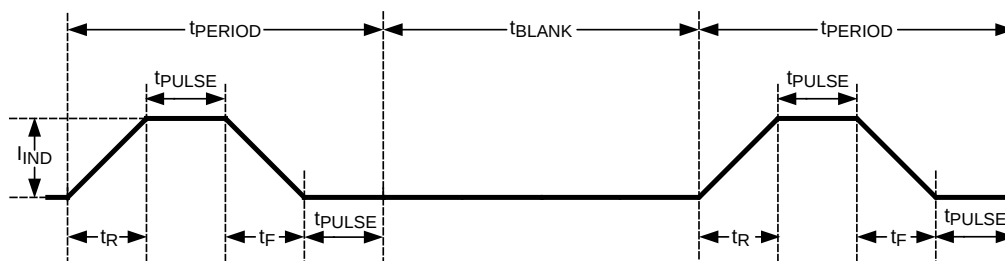
3.15 Indicator Blinking Register

The Indicator Blinking Register field contains the features available in the Indicator Blinking Register. The Pulse Width drop-down menu programs the pulse width time (t_{PULSE}), and the # Blank Period drop-down menu programs the number of blank periods. These relate to the Indicator Timing Diagram by the following three identities:

1. Number of periods ($t_{PERIOD} = t_{RAMP} \times 2 + t_{PULSE} \times 2$)
2. Active Time ($t_{ACTIVE} = t_{PERIOD} \times PERIOD\#$)
3. Blank Time ($t_{BLANK} = t_{ACTIVE} \times BLANK\#$)
 - (see [Table 13](#))

Table 13. Indicator Blinking Register (Address 0x13)

Bits 7 - 4 (# Blank Periods)	Bits 3 - 0 (Pulse Width (t_{WIDTH}))
0000 = 0 (Default) 0001 = 1 0010 = 2 0011 = 3 0100 = 4 0101 = 5 0110 = 6 0111 = 7 1000 = 8 1001 = 9 1010 = 10 1011 = 11 1100 = 12 1101 = 13 1110 = 14 1111 = 15	000 = 0 (Default) 0001 = 32 ms 0010 = 64 ms 0011 = 96 ms 0100 = 128 ms 0101 = 160 ms 0110 = 160 ms 0111 = 224 ms 1000 = 256 ms 1001 = 288 ms 1010 = 320 ms 1011 = 352 ms 1100 = 384 ms 1101 = 416 ms 1110 = 448 ms 1111 = 480 ms


Figure 5. Indicator Timing

3.16 Configuration Register 1

The Configuration Register 1 field contains the buttons for setting each bit within Configuration Register 1. Each time a bit is set, the Register is updated with the new register data.

Table 14. Configuration Register 1 (Address 0xE0)

Bit 7 (Hardware Torch Mode Enable)	Bit 6 (TX2 Polarity)	Bit 5 (TX1 Polarity)	Bit 4 (NTC Mode Enable)	Bit 3 (STROBE Polarity)	Bit 2 (STROBE Input Enable)	Bit 1 (Not Used)	Bit 0 (Not Used)
0 = TX1/TORCH pin is a TX input (default)	0 = TX2 is configured for active low polarity	0 = TX1 is configured for active low polarity	0 = LEDI/NTC pin is configured as an indicator output (default)	0 = STROBE Input is active low. Pulling STROBE low will turn on Flash current	0 = STROBE Input Disabled (default)	N/A	N/A
1 = TX1/TORCH pin is a hardware TORCH enable	1 = TX2 is configured for active high polarity (default)	1 = TX1 is configured for active high polarity (default)	1 = LEDI/NTC is configured as a comparator input for an NTC thermistor.	1 = STROBE Input is active high. Pulling STROBE high will turn on Flash current (default)	1 = STROBE Input Enabled		

3.17 Configuration Register 2

The Configuration Register 2 field contains buttons for setting each bit within the Configuration Register 2. Once the buttons are set, the LM3559/LM3560 is written with the new register data. [Table 15](#) shows the bits settings for Configuration Register 2.

Table 15. Configuration Register 2 (Address 0xF0)

Bit [7:5] (Not Used)	Bit 4 (TX1 Shutdown, LM3560 Only)	Bit 3 (VIN Monitor Shutdown)	Bit 2 (Alternate External Torch Mode)	Bit 1 (NTC Shutdown)	Bit 0 (TX2 Shutdown)
N/A	0 = TX1 interrupt will force the LED current to the programmed torch current level (default)	0 = Input voltage falling below the programmed VIN Monitor threshold will force the LED current into the programmed torch current. (default)	0 = AET Mode Disabled (default)	0 = Voltage at LEDI/NTC falling below VTRIP will force the LED current into the programmed torch current. (default)	0 = TX2 interrupt will force the LED current into the programmed torch current (default)
	1 = TX1 interrupt will force the LED current into shutdown.	1 = Input voltage falling below the programmed VIN Monitor threshold will force the LED current into shutdown.	1 = AET Mode Enabled	1 = Voltage at LEDI/NTC falling below VTRIP will force the LED current into shutdown.	1 = TX2 interrupt will force the LED current into shutdown.

3.18 General-Purpose Input/Output (GPIO) Register

The GPIO Register field contains the buttons and drop-down menus to configure the GPIO Register. The GPIO1 Control and GPIO2 Control provide the drop-down menus for setting the particular pin as either an input or an output. The GPIO1 Data and GPIO2 Data display the data (GPIO Output) or will read back the data (GPIO Input) that is entered in the respective field. When configuring the GPIO's as outputs, a double write is required to the GPIO register. For example, if both GPIO's are inputs, in order to make both GPIO outputs, two writes of b00X11X11 to the GPIO register are required. (X represents the output data). The drop-down menus which contain the GPIO write commands take this into account, so when the LM3559 or LM3560's Graphical User Interface program is used, the double write process is not required.

When configured as inputs, in order to read back a change of data on the GPIO input, the particular GPIO pin must be reconfigured as an input (Write) and then the data on the pin can be read back (Read). For example, if both GPIO pins are inputs and the previous data on the pin was a logic '1', but then changed to a logic '0', in order to read the logic '0' into the GPIO register the read sequence would first be a Write of (b00X01X01) to register 0x20, then a Read of register 0x20 would be done to read in the new data. The GPIO Read button is available to read back the contents of the GPIO Data fields (GPIO Inputs Only). This button takes into account the Write /Read (2 instruction process) so only a push of the Read button is required to read in the contents of the GPIO lines.

The Interrupt Enable button controls the interrupt option available for GPIO2.

Table 16. GPIO Register (Address 0x20)

Bit 7 (Not Used)	Bit 6 (TX2/INT/GPI O2 Interrupt Enable)	Bit 5 (TX2/INT/GPI O2 data)	Bit 4 (TX2/INT/GPIO 2 data direction)	Bit 3 (TX2/INT/GPIO 2 Control)	Bit 2 (TX1/TORCH/ GPIO1 data)	Bit 1 (TX1/TORCH/ GPIO1 data direction)	Bit 0 (TX1/TORCH/ GPIO1 Control)
N/A	0 = TX2/INT/GPI O2 is configured according to bit 3 of this register (default)	This bit is the read or write data for GPIO2 in GPIO mode (default)	0 = TX2/INT/GPIO 2 is a GPIO Input (default)	0 = TX2/INT/GPIO is configured according to the Configuration Register bit 5 (default)	This bit is the read or write data for GPIO1 in GPIO mode (default)	0 = TX1/TORCH/G PIO1 is a GPIO input (default)	0 = TX1/TORCH/G PIO1 pin is configured as a active high hardware enable (default)
	1 = with bits [4:3] = 11, TX2/INT/ GPIO2 is an interrupt output. See Interrupt section.		1 = TX2/INT/GPIO 2 is a GPIO Output	1 = TX2/INT/GPIO 2 is configured as a GPIO		1 = TX1/TORCH/G PIO1 is an output	1 = TX1/TORCH/G PIO1 pin is configured as a GPIO

3.19 VLED Monitor Register

The VLED Monitor section provides the fields for configuring and reading from the VLED Monitor Register. The VLED Monitor Read button reads back the contents of the VLED Monitor Register and populates the fields in the VLED Monitor section with the register contents. The LED Forward Voltage section displays the nominal forward voltage reading from bits [3:0]. The thresholds are different between the LM3559 and LM3560 (see [Section 3.20](#)). The LED forward voltage field displays the midpoint of the voltage range. The Manual Read button performs a manual conversion and updates the LED Forward Voltage section. The ADC Shutdown button disables/enables the ADC.

Table 17. VLED Monitor Register (Address 0x30)

Bit 7 (Not Used)	Bit 6 (End of Conversion, Read Only)	Bit 5 (Shutdown)	Bit 4 (Manual Conversion)	Bit 3 (ADC3)	Bit 2 (ADC2)	Bit 1 (ADC1)	Bit 0 (ADC0)
N/A	0 = Conversion in progress (default)	0 = ADC is enabled. A conversion is initiated automatically at the start of a flash pulse (default)	0 = ADC is set up according to bit 5 (default)	see (Section 3.20)			
	1 = Conversion done.	1 = ADC is shutdown.	1 = Manual Conversion is initiated provided that bit 5 = 0. Bit 4 is reset to 0 when a manual conversion is complete.				

3.20 VLED Monitor Thresholds (LM3559 and LM3560)

LM3559	LM3560
0000 (VLED < 3.2V)	0000 = (VLED < 2.8V)
0001 (3.2V ≤ VLED ≤ 3.3V)	0001 = (2.8V ≤ VLED < 2.9V)
0010 (3.2V ≤ VLED ≤ 3.3V)	0010 = (2.9V ≤ VLED < 3.0V)
0011 (3.3V ≤ VLED ≤ 3.4V)	0011 = (3.0V ≤ VLED < 3.1V)
0100 (3.4V ≤ VLED ≤ 3.5V)	0100 = (3.1V ≤ VLED < 3.2V)
0101 (3.5V ≤ VLED ≤ 3.6V)	0101 = (3.2V ≤ VLED < 3.3V)
0110 (3.6V ≤ VLED ≤ 3.7V)	0110 = (3.3V ≤ VLED < 3.4V)
0111 (3.7V ≤ VLED ≤ 3.8V)	0111 = (3.4V ≤ VLED < 3.5V)
1000 (3.8V ≤ VLED ≤ 3.9V)	1000 = (3.5V ≤ VLED < 3.6V)
1001 (3.9V ≤ VLED ≤ 4.0V)	1001 = (3.6V ≤ VLED < 3.7V)
1010 (4.0V ≤ VLED ≤ 4.1V)	1010 = (3.7V ≤ VLED < 3.8V)
1011 (4.1V ≤ VLED ≤ 4.2V)	1011 = (3.8V ≤ VLED < 3.9V)
1100 (4.2V ≤ VLED ≤ 4.3V)	1100 = (3.9V ≤ VLED < 4.0V)
1101 (4.3V ≤ VLED ≤ 4.4V)	1101 = (4.0V ≤ VLED < 4.1V)
1110 (4.4V ≤ VLED ≤ 4.5V)	1110 = (4.1V ≤ VLED < 4.2V)
1111 (4.5V ≤ VLED ≤ 4.6V)	1111 = (4.2V ≤ VLED)

3.21 ADC Delay Register

The ADC Delay Register sets the delay from when the Flash LED current hits its target value to when a conversion is performed, or the delay from when bit 4 goes high to when a manual conversion is performed. The ADC Delay Enable button sets whether the delay is effectively 0 or is set via the ADC Delay drop-down menu.

Table 18. ADC Delay (Address 0x31)

Bits [7:6] (Not Used)	Bit 5 (ADC Delay Disable)	Bits [4:0] (ADC Delay)
N/A	0 = ADC Conversion delay set via bits [4:0] (default) 1 = No delay from when the LED current hits the target current level or from when the Manual conversion bit is set to '1', to when a conversion is performed.	Bits [4:0] set the delay from when the flash LED current hits its nominal value to when a conversion is performed. This is also the delay from when the Manual conversion bit is set to '1' to when a conversion is performed. Settings are in increments of 250 μs. 00000 = 250 μs 00001 = 500 μs : : : : : : 11111 = 8ms

3.22 Flags Register

The Flags Register is a read only register. The Flags Register field contains 8 fields that display each flag in the register. Pushing the Read Flags button will read the contents of the Flags Register and populate the Flags Register fields with the appropriate data.

Table 19. Flags Register Settings (0xD0)

Bit 7 (VIN Monitor)	Bit 6 (VIN Flash Monitor)	Bit 5 (NTC Fault)	Bit 4 (TX2 Interrupt)	Bit 3 (TX1 Interrupt)	Bit 2 (Led Fault)	Bit 1 (Thermal Shutdown)	Bit 0 (Flash Timeout)
0 = VIN is above the VIN Monitor Threshold or VIN Monitor Threshold is Disabled	0 = VIN did not fall below the VIN Flash Monitor threshold during the flash pulse turn-on or VIN Flash Monitor is disabled	0=LED/NTC pin is above 1V	0=TX2 has not changed state	0=TX1 has not changed state	0 = Proper LED Operation	0 = Die Temperature below Thermal Shutdown Limit	0 = Flash Time-Out did not expire

Bit 7 (VIN Monitor)	Bit 6 (VIN Flash Monitor)	Bit 5 (NTC Fault)	Bit 4 (TX2 Interrupt)	Bit 3 (TX1 Interrupt)	Bit 2 (Led Fault)	Bit 1 (Thermal Shutdown)	Bit 0 (Flash Timeout)
1 = VIN Monitor is Enabled and VIN has Fallen below the programmed threshold.	1 = VIN Flash Monitor is enabled and VIN fell below the programmed VIN Flash Monitor threshold during the flash pulse turn-on	1=LED/NTC has fallen below 1V (NTC mode only)	1=TX2 has changed state	1=TX1 has changed state	1 = LED Failed (Open or Short	1 = Die Temperature has crossed the Thermal Shutdown Threshold	1 = Flash Time-Out expired

The Last Flash Register is a read only register that is updated with the Flash Brightness data for both LED1 and LED2 when the Input Flash Monitor is enabled and the input voltage falls below the programmed VIN Flash Monitor Threshold (see VIN Monitor Register). When the Last Flash Read button is pushed the data field is populated with the contents of the Last Flash Register (displayed as nominal current set points).

Bit 7 (LF2A)	Bit 6 (LF2B)	Bit 5 (LF2C)	Bit 4 (LF2D)	Bit 3 (LF1A)	Bit 2 (LF1B)	Bit 1 (LF1C)	Bit 0 (LF1D)
These bits are read only and represent the Flash Current Code for LED2 that the LM3559/LM3560 was at during the last flash during an interrupt. see Table 5 and Table 6				These bits are read only and represent the Flash Current Code for LED1 that the LM3559 was at during the last flash during an interrupt. see Table 5 and Table 6			

The LM3559/LM3560 board layout is shown in (Figure 6, Figure 7, Figure 8, and Figure 9)

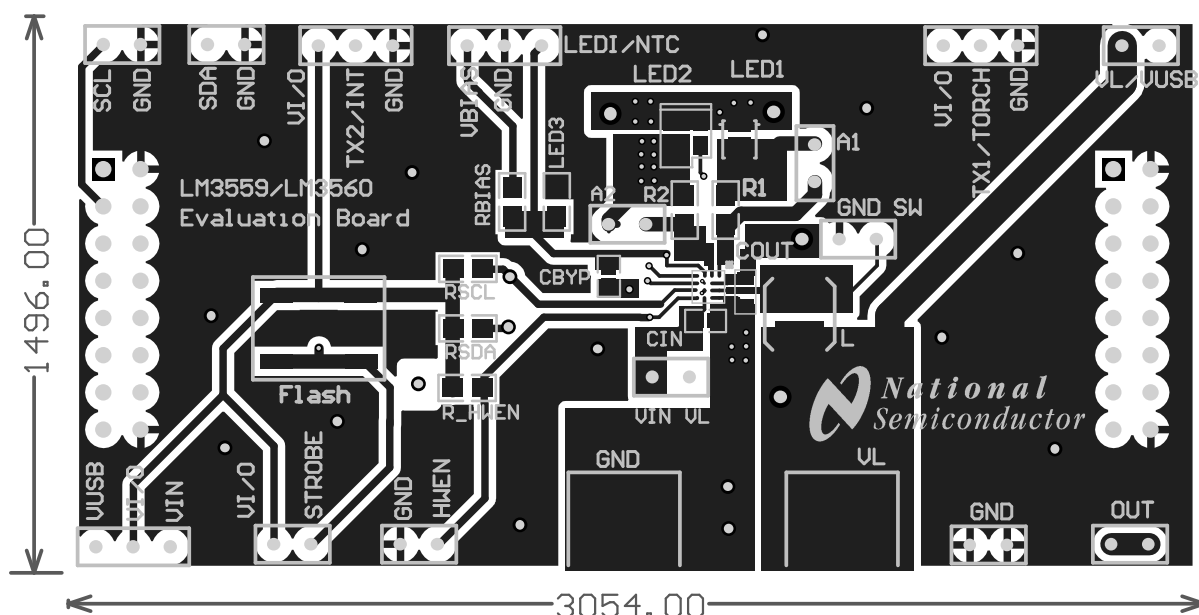


Figure 6. Board Layout (Top Layer)

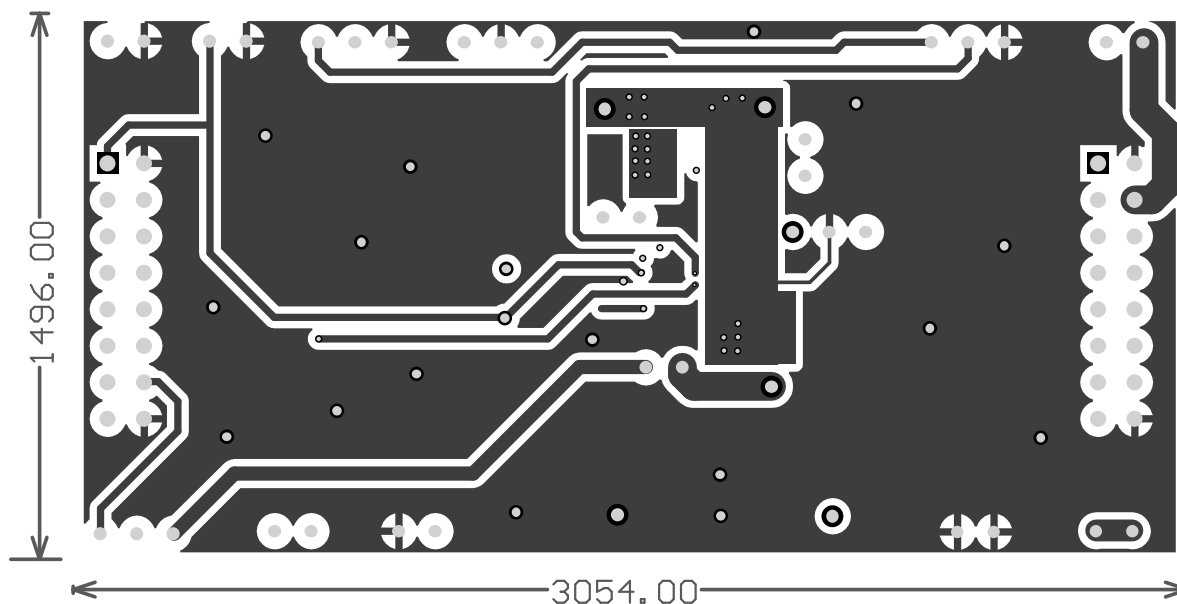


Figure 7. Board Layout (Mid Layer 1)

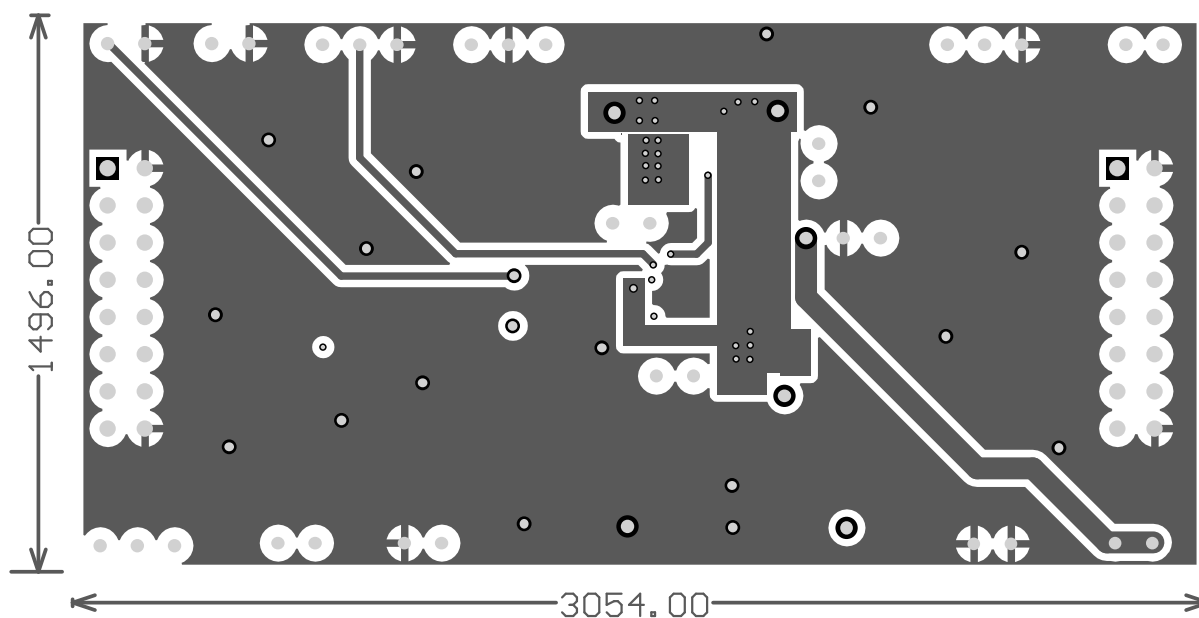


Figure 8. Board Layout (Mid Layer 2)

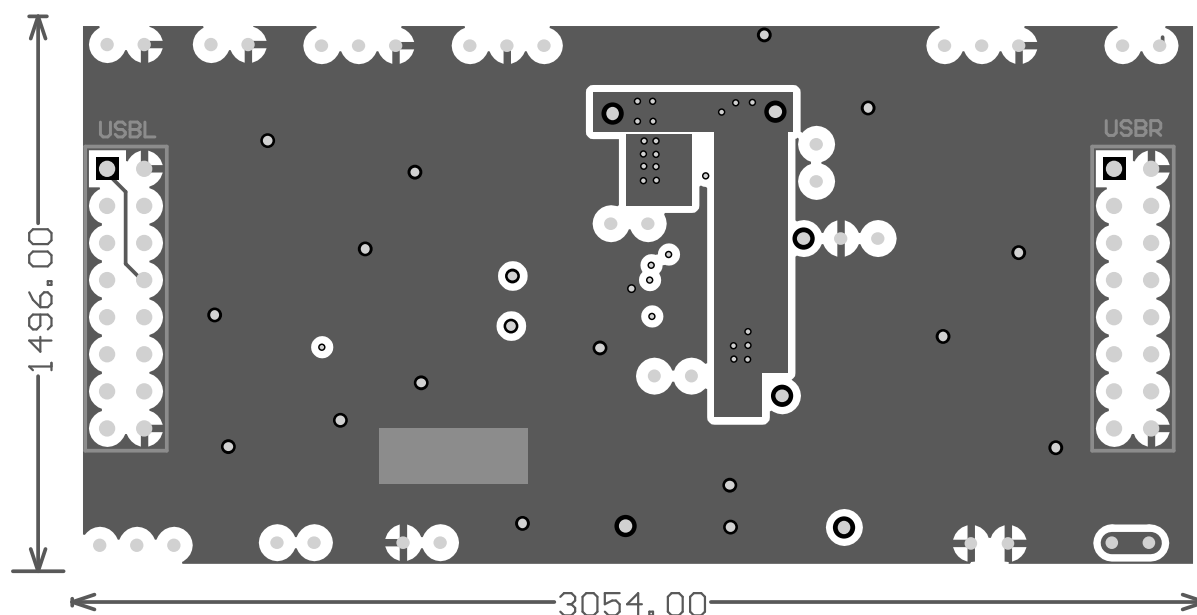


Figure 9. Board Layout (Bottom Layer)

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

- 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software
- 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

- 2 *Limited Warranty and Related Remedies/Disclaimers:*

- 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
- 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
- 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

- 3 *Regulatory Notices:*

- 3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

3.3.3 *Notice for EVMS for Power Line Communication:* Please see http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page
電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMS are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMS, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2015, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com